SESSION 6

MEASUREMENT

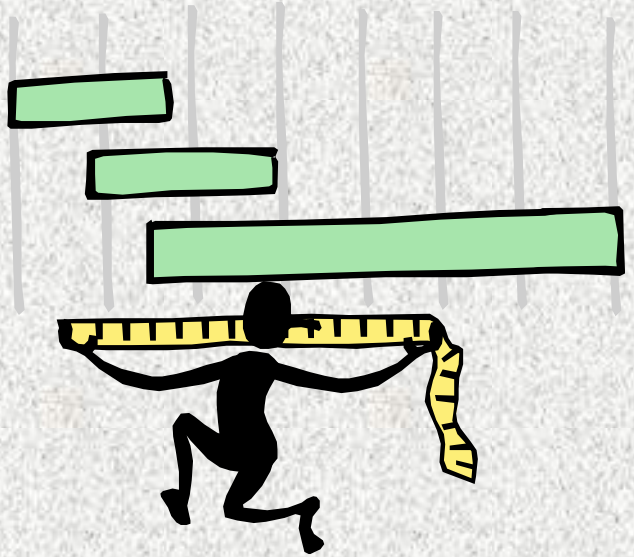
AND

VERIFICATION

(M&V)

OVERVIEW

- What is a Baseline?
- What is M&V
- Potential Trouble Spots
- Rules of Thumb
- Conclusions



WHAT IS A BASELINE?

- What is a Baseline?
- Why is a Baseline important?
- How is a Baseline prepared?

WHAT IS AN ENERGY BASELINE?

An Energy Baseline is a prediction of the amount of energy that would have been used if there had not been any energy conservation equipment installed

WHAT IS M&V?

- Verifies the baseline conditions are accurately defined
- Verifies the ECP's actual savings
- Used to certify payment to ESCO

WHAT'S OUT THERE?

- The International Performance Measurement and Verification Protocol (IPMVP)
  - Collaborative effort with industry, financial and government
  - Used by ESCOs
  - Provides four basic options
- FEMP M&V used by many ESCOs
  - Numerous options and equations
  - Defines levels of accuracy and cost
- AFCESA has created a user friendly, step-by-step guide to M&V

WHAT ARE THE OPTIONS?

- Option A, Engineering calculations with spot metering, simplistic approach
- Option B, metering required for each system used (long -term)
- Option C, whole building evaluation including historical data, metering
- Option D, Computer simulation

THE M&V PLAN

- M&V plans specify:
  - Goals and objectives
  - Characteristics of the facility and the ECM
  - M&V Option, method and analyses techniques
  - Metering points, periods and protocols
  - Quality assurance procedures
  - Reporting and documentation procedures

POTENTIAL TROUBLE SPOTS

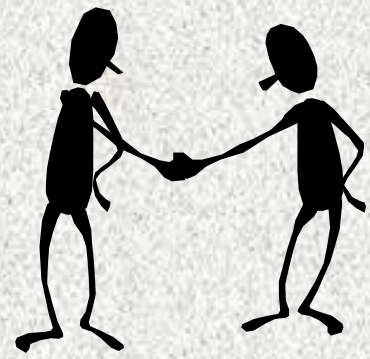
- Rate blending of all ECMs can cost you dollars
- Double counting savings
- Maintenance savings beyond the “normal”
- Military unique, i.e. no heat/no cool periods

RULES OF THUMB

- No best approach for developing the baseline
- Use M&V option most appropriate for task
- Considerations
  - Accuracy vs Cost
  - Accuracy vs Ease of Use
  - Accuracy vs Contractor Risk

CONCLUSIONS

- M&V
  - Defines the savings potential for each ECP & ECM
  - Verifies results of the installed equipment
  - Must be agreed to up front!!
  - Adjustments should be included
  - Should validate yearly, spot check when possible



QUESTIONS?

Measurement and Verification

Of Energy Savings
Performance
Contracts

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What is Measurement & Verification ?

- Definitions
- Uses
- Perspectives
- History
- Three Protocols
- Options & Methods; Procedures

M&V Aliases?

- Measurement & Verification
- Measurement & Monitoring
- Measurement & Evaluation
- Metering & Monitoring
- Monitoring & Evaluation

Measurement & Verification (M&V)

- North American Energy ***Measurement &Verification*** Protocol (NEMVP)

- FEMP ***Measurement & Verification*** Guidelines

DEFINITIONS

MEASURE

- ***Measure*** (*v*) to ascertain the quantity, mass, extent or degree...by means of an instrument …marked off in units
- ***Measure*** (*n*) an action planned or taken toward the accomplishment of a purpose

METER

- ***Meter*** (*n*) an instrument for measuring and recording the amount of something as it flows

- ***Meter*** (*v*) to measure by means of a meter

MONITOR

- ***Monitor*** (*v*) to watch, observe, or check, esp. for a special purpose;

- to keep track of, regulate, or control

EVALUATION

- ***Evaluation*** (*v*) to estimate, or ascertain the monetary worth;
- to examine and judge, concerning the worth, quality, significance, amount, degree or condition

VERIFICATION

- ***Verification*** (*v*) to confirm or substantiate in law by oath or proof;
- to prove to be true/conclusively demonstrate by presentation of facts or by sound reasoning or argument

M&V DOCUMENTS: A Common Language

- **Performance Contracting** has created a need for many people to work together
- **M&V** is a new language for new partnerships

M&V USES

Uses of M&V

- Determine energy savings
- Commissioning of ECMs
- Long term feedback (Continuous Commissioning)

Uses of M&V (cont)

- ECM Evaluation Documentation
- Procurement - Building Trust
- Annual Energy Audit
  - Required by regulation for ESPC (performance-based contracting)

M&V PERSPECTIVES

M&V Perspectives

- An ***engineering*** issue for engineers
- A ***contract*** issue for contractors and contracting officials
- A ***procurement*** issue for source selection officials

What is M&V?

Engineers Install Nega-Watt Meters

- **Measure** performance before/after installation of Energy Conservation Measures (ECMs)
- **Verify** that ECMs perform and generate savings
- **Monitor** to assure consistent operation
- **Quantify** energy savings by comparing pre- and post installation energy use (performance)

The Truth About Energy Savings

- Energy Savings are ***intangible***.
- 'Energy Savings' can't be **measured**...but...

Energy Performance *can!*

Energy Savings

- Energy Savings are:
  - **Determined**
  - **Calculated**
  - **Assessed**

Energy Savings

- **Energy Savings =**

Performance Measurements

+

Assumptions (baseline model)

Definition

- ***Baseline is the calculated and/or measured energy use prior to implementation of project ECMs.***

Defining the Baseline

- Measured performance and savings
- What is an adjustment?
- What variables require an adjustment?
- How does the contract handle adjustments?

Definition

Adjusted Baseline. The Baseline is subject to adjustment due to changes beyond the contractor's control.

Baseline Adjustments

- Physical changes to a building
- Occupancy or usage changes
- Area or space condition changes
- Removing or adding energy-consuming equipment
- Weather changes
- Utility rate changes
- Changes in energy-consuming equipment operating conditions

What is M&V?
The *Contracting* View

- Agreement between agency and ESCO
- Establishes the Basis of Payment
- Guaranteed Savings
- Customer Satisfaction- Proving Success

What is M&V?
The *Contracting* View (cont)

- Risk Allocation- defining variables and assigning responsibility
- Three Categories of Risk
  - ESCO Responibility
  - Agency Responsibility
  - Neither Party (Weather, Utility Rates)

Risk Allocation:

- Which party is responsible for the performance of the ECM?
- Which party is responsible for achieving long term savings (operation)?

Risk Allocation:

- Which party is responsible for the weather?
- Which party is responsible for changes in utility rates?
- What other changes may occur?

Risk Allocation (cont)

- Issues of Risk Allocation are covered in the Contract
- The M&V Plan uses the Option that best fits the needs of the contract

Performance vs Operation

- ***Performance:*** Characteristic of the system, defined in units of energy, time etc. (power)
  - »**Automobile:** miles per gallon (mpg)
  - »**Lighting System:** watts / square foot
  - »**Chiller**: kW/ton

Performance vs Operation

- ***Operation:*** the integrated effect of performing systems (i.e. the "energy" used over time)
  - »**Automobile:** miles driven per year
  - »**Lighting System:** hours of operation
  - »**Chiller:** ton-hours of operation

What is M&V?
The *Procurement* View

- Source Selection
- Choosing the right partner
- Understanding the nature of the partnership (Agency & ESCO)

What is M&V?
The *Procurement* View (cont)

- Assuring that the Agency and the ESCO are using the same assumptions
- Assuring that the Agency and the ESCO are speaking the same language (Protocols)

HISTORY of M&V

Who Defines M&V?

- Federal, State, Local Government
- Industry
- Utilities
- ESCOs (Energy Service Companies)
- NAESCO (National Association of Energy Service Companies)
- ASHRAE
- AEE (Association of Energy Engineers)
- Universities

M&V Protocols (highlights)

- 1970's case by case measurement
- 1985 first utility-sponsored large scale programs
- 1988 New Jersey M&V Plan
- 1988 First NAESCO M&V Plan

M&V Protocols (highlights)

- 1992 **California CPUC** *M&V Protocol*
- 1992 **New Jersey** *Standard Offer Protocol*
- 1992 **Bonneville Power Administration**

M&V Protocols (highlights)

- 1993 **New England AEE** *M&V Protocol*
- 1993 **NAESCO** *M&V ver 1.3*
- 1994 **PG&E** *PowerSaving Partners "Blue Book"*

M&V Protocols (highlights)

- 1995 **EPA** *Conservation Verification Protocols*
- 1995 **LoanSTAR** (Texas) *Protocols*

M&V Protocols (highlights)

- 1996 **NEMVP**
- 1996 **FEMP** *M&V Guidelines*
- 1997 IPMVP
- 1997 ASHRAE RP-827
- 1998 **ASHRAE** 14-P

Three M&V Documents

IPMVP

- IPMVP: International Performance Measurement and Verification Protocol
- NEMVP>>IPMVP
- New version later in 1997
- General guidelines / framework
- Definitions for M&V

IPMVP (cont)

- Water Efficiency
- New Construction
- Indoor Air Qualtiy
- EPA Emissions Credits

FEMP M&V Guidelines

- For federal energy projects
- Step by step procedural guide
- Defines M&V methods by ECM type

ASHRAE GPC14-P

- ASHRAE: American Society of Heating Refrigeration and Air-Conditioning Engineers
- ASHRAE 14-P Guideline for Measurement of Energy and Demand Savings
- Meetings every 6 months

ASHRAE GPC14-P

- Technical details about M&V, methods, and techniques
- Draft for review 1998
- To be released summer 1998

What the Protocols Cover

- Options A,B,C and D
- Agreement Language
- New packaging of established engineering techniques. (No new engineering information.)

What the Protocols Cover

- Selecting the Right Option for a Project
- Overview of Procedures
- IPMVP packed with references for additional information on M&V

What the Protocols Don't Cover Now

- Operations and Maintenance
- Detailed Metering Specifications, or instrumentation guidance
- Calculating the cost of M&V
- Scientific/Engineering Rationale for adjusting the baseline for multiple dependent variables (Sorry)

To Obtain the Protocols:

- Contact EREC at 1-800 363-3732 (1-800-DOE-EREC)
- ***IPMVP*** http://www.bmvp.org
- ***FEMP*** http://eande.lbl.gov/CBS/femp/MVdoc.html

Options & Methods

Definitions

- ***Options***: four approaches defined in IPMVP and FEMP M&V Guidelines (three options in ASHRAE 14-P)

- ***Methods***: M&V approach applied to a specific ECM technology

M&V Options

- Four M&V Options, defined in the 1997 IPMVP and FEMP
- ASHRAE defines three options
  - Retrofit Isolation (B)
  - Whole-Building Analysis (C)
  - Calibrated Simulation (D)

M&V Options

- No option is necessarily better or more/less expensive than another
- Each M&V option is applicable to different situations

Why Options A/B/C/D?

- **Options** address risk allocation
- Measurements differ by
  - **degree of stipulation**
  - **level**
  - **duration**

Measurement Levels

- **System**

  Option A
  Option B

- **Whole Building**

  Option C
  Option D

Measurement Duration

- **Periodic** Option A
- **Continuous** Options B,C
- **Combination** Option D

Option A
(Performance Warranty)

- Measured Performance-Stipulated Operation
- For projects where verifying the potential to perform is the major concern (or the risk to be mitigated)

Option A
(Performance Warranty)

- Determine operation for baseline
- Measure performance before and after retrofit
- Calculate Savings based on stipulated operation

Option A Verification:

- Were proper equipment/systems installed? (The right stuff?)
- Are the systems performing to specification? (Does it work?)

Option A Verification:

- Do systems have the potential to generate predicted savings?
- Does the equipment continue to perform through the term of the contract?

Option A Issues

- Measures *performance*, not *operation*
- Cannot measure *interactions* between systems (lighting and cooling)
- Indicates whether the equipment is performing to specification

Option B

- Measured Performance - Measured Operation

- For projects where performance **and** operation needs to be verified on a system level

Option B (cont)

- Same as Option A ***plus*** continuous measurement of performance (post-installation energy use) throughout the contract term
- 'Retrofit Isolation' in ASHRAE GPC-14P

Option B Issues

- Does not measure interactions
- Always involves specialized end-use metering and subsequent data analysis

Option C

- Whole-Building Measurement
- For projects where whole-building analysis is required or suffices for verification of retrofit savings
- Requires utility bill whole-building meter analysis, or hourly whole-building data

Option C (cont)

- Baseline is often normalized to weather or other independent variable (regression model)
- Savings are determined by comparing energy use to baseline, as predicted by regression model

Option C Issues

- All the metering you need is often installed (utility billing meter)
- Seeing results in the utility bill increases confidence (but does not necessarily prove that the retrofit worked)
- Captures interactive effects

Option D

- Use of a calibrated simulation tool to estimate ‘before’ and ‘after’ energy use
- Simulation for a whole building

Option D (cont)

- Building simulation model (e.g. DOE-2) or a spreadsheet, or some other estimating tool
- The calibration is a comparison of simulation model predictions with end-use or whole building data

Option D Issues

- Can be very accurate
- Always requires detailed data and analysis ($$$$)

FEMP
M&V Procedures

- General Approach to M&V
- FEMP Steps
- Components of M&V

General Approach to M&V

- Compare energy use before and after retrofit
- “Before” case used to create baseline
- “After” case has two components

"After"- (Post Installation)

- Post Installation Energy Use
  - **Baseline Energy Use (Adjusted)**
  - **Measured Performance**

Six Steps of M&V

- Define a general M&V approach
- Define a site-specific M&V plan for the particular project
- Define pre-installation baseline
- Define post-installation situation/energy use

Six Steps of M&V (cont)

- Calculate energy savings for the first year. Calculate first year payments
- Conduct annual M&V activities / calculate or verify annual payments

STEP 1:
Define an M&V Approach

- Establish a preferred M&V method for the retrofit
- Coordinate the preferred M&V method with contract provisions
- Calculate value of ECM(s) to define relative value the M&V information

STEP 2 Create a Site-Specific M&V Plan

- Perform Site Inspection
- Identify physical characteristics that affect M&V
- Identify Operating characteristics of ECM

STEP 2 Create a Site-Specific M&V Plan (cont)

- Based on results of Site Inspection, select appropriate M&V Option
- Develop and document M&V plan per protocols

STEP 3: Collect Baseline Information

- Utility Bills
- Short Term metered data on:
  - End-Use systems
  - Individual Equipment
  - Manufacturer's Specifications

STEP 3: Collect Baseline Information (cont)

- Weather Data
- Equipment counts and locations
- Photographs of major equipment
- Existing conditions (i.e. light levels, temps)

STEP 3: Collect Baseline Information (cont)

- Operating schedules
- Occupancy schedules
- Other energy-use related information

STEP 4:Verify ECM Installation & Performance

- Were proper equipment/systems installed? (Is it the right stuff?)
- Are the systems performing to specification (Does it work?)

STEP 4:Verify ECM Installation & Performance

- **Techniques:**
  - Inspections
  - Spot measurement tests
  - Commissioning activities

STEP 4:Verify ECM Installation & Performance

- Commissioning activities include:
  - Document design assumptions
  - Document design intent
  - Test Functional performance
  - Adjust the ECM to meet actual needs
- ASHRAE's GPC-1 can be the resource document

STEPS 5-6: Calculate Energy Savings

- Step 5: Calculate first year savings
- Step 6: Conduct Annual M&V Activities
- Determine actual energy savings achieved by the installed ECM per instructions in the M&V Protocols

Review of Options

- ***Option A***: Verifying performance of retrofit. Operation is stipulated

- ***Options B:*** Continuous measuring performance and operation of retrofit

Review of Options (cont)

- ***Option C:*** Continuous measuring performance and operation of whole building
- ***Option D***: Calibrated simulation - (hybrid of A and B or C)

M&V Issues

- Defining the baseline and keeping it “up to date” (adjustments)
- Energy costs
- How much M&V is enough?

Issue - The Baseline

- How long does the baseline have to be measured?
- Are there alternatives to long term pre-installation measurements?
  - lighting?
  - chillers?

Issue - The Baseline

- Define (before the fact) what influences the baseline and when will it be modified, e.g.:
  - Changes to owner identified variables
  - Changes to “outside” variables
  - Implicit vs. Explicit variables

How Much M&V is Enough?

- ***Option A***: 1% - 5% of project costs
- ***Option B***: 1% - 15% of project costs
- ***Option C***: 1% - 10% of project costs
- ***Option D***: 3% - 15% of project costs

How Much M&V is Enough?

- Using different “levels” of accuracy and risk avoidance can be the basis for differences in pricing and financing rates for performance contracts

Fundamentals

- "**Savings**" are intangible. Performance is measurable

- Measured Performance and **a**ssumptions about the baseline are used to determine Savings

Fundamentals

- Measurement and Verification provides standard language to agree on those assumptions
- For the contract to be a success, both parties must understand the agreement and M&V strategy

Measurement & Verification for ESPC Contracts

In ESPC satellite broadcasts, the class views a tape at this time.

Measurement & Verification for Energy Savings Performance Contracts June 1999 is available for order from the following sites:

1. Internet: http://www.eren.doe.gov/femp/ordermaterials.html
   Select Energy Savings Performance Contracts
   Select M&V Guidelines for ESPC Videotape
2. Phone: 1-800-363-3732
3. E-Mail: doe.erec@nciinc.com

The following slides continue to be used as a M&V reference.